PhytoKeys

PhytoKeys 252: 25–40 (2025)
DOI: 10.3897/phytokeys.252.133501

Research Article

Gastrochilus obovatifolius (Orchidaceae, Aeridinae), a new species from the Daba Mountains of Chongqing, China

Chi Xiong[1*], Xiao-Ying Fu[2*], Ke Tan[1], Ya Huang[3], Hong-Jing Zhang[3], Yi-Chen Wang[4], Yu-Bing Yang[5], Si-Rong Yi[3]

1 *Guangxi Key Laboratory of Plant Conservation and Restoration Ecology in Karst Terrain, Guangxi Institute of Botany, Guangxi Zhuang Autonomous Region and Chinese Academy of Sciences, Guilin, 541006, Guangxi, China*
2 *College of Life Sciences, Guangxi Normal University, Guilin 541006, Guangxi, China*
3 *Chongqing Key Laboratory of Development and Utilization of Genuine Medicinal Materials in Three Gorges Reservoir Area, Chongqing Three Gorges Medical College, Wanzhou, Chongqing, 404120, China*
4 *Hangzhou Botanical Garden, Hangzhou, 310013, China*
5 *Center for Biodiversity Conservation and Utilization, Key Laboratory of Eco-Environment in the Three Gorges Reservoir Region, Ministry of Education, School of Life Sciences, Southwest University, 400715, Beibei, Chongqing, China*

Corresponding author: Si-Rong Yi (yisirong123@aliyun.com)

Abstract

Gastrochilus obovatifolius, a new species discovered in the Dabashan of northeast Chongqing (China), is described and illustrated. The novelty morphologically resembles *G. affinis*, *G. balangshanensis* and *G. heminii* in having a glabrous and smooth epichile. but can be distinguished by the unique obovate shape of the leaves, smaller epichile, and flower color. The results of molecular phylogenetic analysis, based on nuclear ribosome internal transcribed spacer (nrITS) and four chloroplast DNA fragments (*mat*K, *psb*A–*trn*H, *psb*M–*trn*D, and *trn*L–F) of 55 *Gastrochilus* species, support the inclusion of *G. obovatifolius* in *G.* sect. *Microphylli*, being most closely related to *G. balangshanensis* from Sichuan. The new species is a trunk epiphyte in evergreen broad-leaved forest.

Key words: Epidendroideae, Flora of Chongqing, *Gastrochilus* sect. *Microphylli*, phylogeny, Qinling-Daba Mountains, taxonomy

OPEN ACCESS

Academic editor: João Farminhão
Received: 30 July 2024
Accepted: 17 December 2024
Published: 7 February 2025

Citation: Xiong C, Fu X-Y, Tan K, Huang Y, Zhang H-J, Wang Y-C, Yang Y-B, Yi S-R (2025) *Gastrochilus obovatifolius* (Orchidaceae, Aeridinae), a new species from the Daba Mountains of Chongqing, China. PhytoKeys 252: 25–40. https://doi.org/10.3897/phytokeys.252.133501

Copyright: © Chi Xiong et al.
This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0).

Introduction

The orchid genus *Gastrochilus* D.Don (Don 1825: 32) part of the mostly Asian vandoid subtribe Aeridinae, comprises approximately 80 species distributed in tropical and subtropical Asia, from India and Sri Lanka to East Asia and south to Indonesia (Tsi 1996, 1999; Liu et al. 2019; Zhang et al. 2022; Ya et al. 2023; POWO 2024; Zhang et al. 2024a, b). Among these, around 60 species are found in China (including approximately 40 endemic), where new species continue to be regularly described (Chen et al. 2009; Liu 2017; Liu et al. 2019, 2023; Li et al. 2022; Ya et al. 2023; Zhang et al. 2024a, b; Zhou et al. 2024). A recent systematic study has classified *Gastrochilus* into six sections: *Gastrochilus* sect. *Gastrochilus*, *G.* sect. *Pseudodistichi* Jun Y. Zhang & H. He, *G.* sect. *Brachycaules* Q. Liu & J.Y. Gao

* The authors contributed equally to this paper.

ex Jun Y. Zhang & H. He, *G.* sect. *Acinacifolii* Q. Liu & J.Y. Gao ex Jun Y. Zhang & H. He, *G.* sect. *Microphylli* (Benth. & Hook. f.) Seidenf., and *G.* sect. *Caespitosi* Z. H. Tsi (Zhang et al. 2024a). These sections can be delimited by leaf shape and length, type of epichile hairs and margin, and by whether the epichile surface is smooth or not (Zhang et al. 2024a). Recently, the Mountains of Southwest China have emerged as a fertile ground for new species discovery in *G.* sect. *microphylli*, namely the Hengduan Mountains (Liao et al. 2022, Ya et al. 2023, Zhang et al. 2024b), but the Qinling-Daba Mountains, to the east, have received less attention.

The Qinling-Daba Mountains (QDM) constitute a comprehensive geographical and geomorphic entity, serving as a natural demarcation between northern and southern China. These mountains function as an important corridor between the Hengduan Mountains and the eastern plains, separating the warm temperate zone from the subtropical zone (Zhu 1958, Zhang 2019). This region is acknowledged as one of China's foremost biodiversity hotspots, hosting a total of 9,491 species of seed plants, accounting for 39% of the overall seed plant diversity present in China (Zhang et al. 2022a). Moreover, the area is home to 3,585 endemic species, which represent 37% of the vascular plant species found within this region (Zhang et al. 2022b). In March 2024, during a plant survey in Chengkou County, Northeast Chongqing, at the southern foothills of the QDM, we encountered an unknown species of *Gastrochilus* with distichous, alternate, and obovate leaves, and small flowers with dark purple stripes. The smooth and glabrous epichile pointed to its inclusion in *G.* sect. *Microphylli* (Seidenfaden 1988). Some living plants were put into cultivation at Guilin Botanical Garden for further study. Standard herbarium taxonomy, including a comprehensive literature review on the genus (Chen et al. 2009; Liu 2017; Lee et al. 2019; Liu et al. 2019; Rao et al. 2019; Wu et al. 2019; Ormerod and Kumar 2020; Li et al. 2021; Nguyen et al. 2021; Averyanov et al. 2022; Chen et al. 2022; Dey et al. 2022; Liao et al. 2022; Zhang et al. 2022, 2024a, b; Lee et al. 2023; Li et al. 2023; Liu et al. 2023; Ya et al. 2023; Zhou et al. 2024), confirmed that it represents a new species of *Gastrochilus*. In parallel, we investigated the phylogenetic position of *G. obovatifolius* sp. nov., which is here described and illustrated.

Materials and methods

Morphological analyses

Specimens of the novelty were collected during our field expedition to the Chongqing Municipality in 2024. Photographs were taken using a Nikon D7200 digital camera (Japan). Morphological descriptions and measurements were based on living plants and dried herbarium specimens deposited at CGMC and IBK (herbarium acronyms follow Thiers 2024). This material was compared to relevant specimens, including types, presented in Zhang et al. (2024b), housed at CDBI, K, KUN and PE. Descriptive terminology follows Beentje (2016).

Genomic DNA extraction and sequencing

Leaf material for DNA extraction was dried using silica gel (Chase and Hills 1991). Genomic DNA was extracted using a modified CTAB protocol (Chen et al. 2014). The total genomic DNA sample was sent to Majorbio in China

(http://www.majorbio.com/) for library construction and next-generation sequencing. Short-insert (350 bp) paired-end read libraries preparation and 2 × 150 bp sequencing were performed on an Illumina (HiSeq4000) genome analyzer platform. Approximately 1 Gb of raw data for the new species was filtered using the FASTX-Toolkit (http://hannonlab.cshl.edu/fastx_toolkit/download.html) to obtain high-quality clean data by removing adapters and low-quality reads.

Plastid genome and ribosomal DNA (rDNA) assembly and annotation

Complete chloroplast genome and ribosomal genome data were assembled using GetOrganelle v.1.7.7.0 (Jin et al. 2020). ITS sequence extraction was performed by ITSx v.1.1.3 (Bengtsson-Palme et al. 2013). The plastid genome was preliminarily annotated using CPGAVAS2 (Shi et al. 2019), with *Gastrochilus fuscopunctatus* (Hayata) Hayata (GenBank: NC_035830) as the reference genome. The annotation results were confirmed using Geseq (Tillich et al. 2017). The genome map of the new species was drawn by OGDRAW (Greiner et al. 2019). The genome sequences were deposited in GenBank (accession numbers: PP942372, PP949380).

Phylogenetic analyses

To investigate the phylogenetic position of this species, we extracted five DNA regions (ITS, *mat*K, *psb*A–*trn*H, *psb*M–*trn*D, and *trn*L–F) from assembled rDNA and complete plastid genome sequences of the new species. Additionally, we downloaded sequence data used in Zhang et al. (2024a) and Ya et al. (2023) from GenBank (Suppl. material 1). This resulted in 95 accessions representing 61 taxa in total, with 55 taxa belonging to *Gastrochilus* as the ingroup, and six Aeridinae species in the genera *Luisia* Gaudich., *Saccolabium* Blume, *Holcoglossum* Schltr. and *Pomatocalpa* Breda as the outgroup. All sequences were aligned using MAFFT and the five aligned DNA markers were concatenated in Phylosuite v.1.2.3 (Katoh and Standley 2013; Zhang et al. 2020; Xiang et al. 2023). The substitution model was determined in Phylosuite v.1.2.3 using ModelFinder (Kalyaanamoorthy et al. 2017; Zhang et al. 2020; Xiang et al. 2023) and the evolutionary best fit model (GTR+F+I+G4) was selected using the corrected Akaike Information Criterion (AICc). Bayesian Inference (BI) was conducted using MrBayes in Phylosuite v.1.2.3 (Ronquist et al. 2012; Zhang et al. 2020; Xiang et al. 2023). The Markov chains were run for 1,000,000 generations, with sampling every 1,000 generations and a burn-in of 0.25. Four Markov chains with two runs were executed. The Maximum Likelihood (ML) phylogenetic trees were generated in IQ-TREE with 1000 bootstrap replicates in Phylosuite v.1.2.3 (Guindon et al. 2010; Minh et al. 2013; Nguyen et al. 2015; Zhang et al. 2020; Xiang et al. 2023).

Results

The complete plastid genome sequences of *Gastrochilus obovatifolius* sp. nov. comprise 146,248 bp (Fig. 1). The characteristics and statistics of the plastid genome are summarized in Suppl. materials 2, 3. The aligned nrITS matrix is 683 nucleotides long with 207 variable sites, and the combined four plastid markers

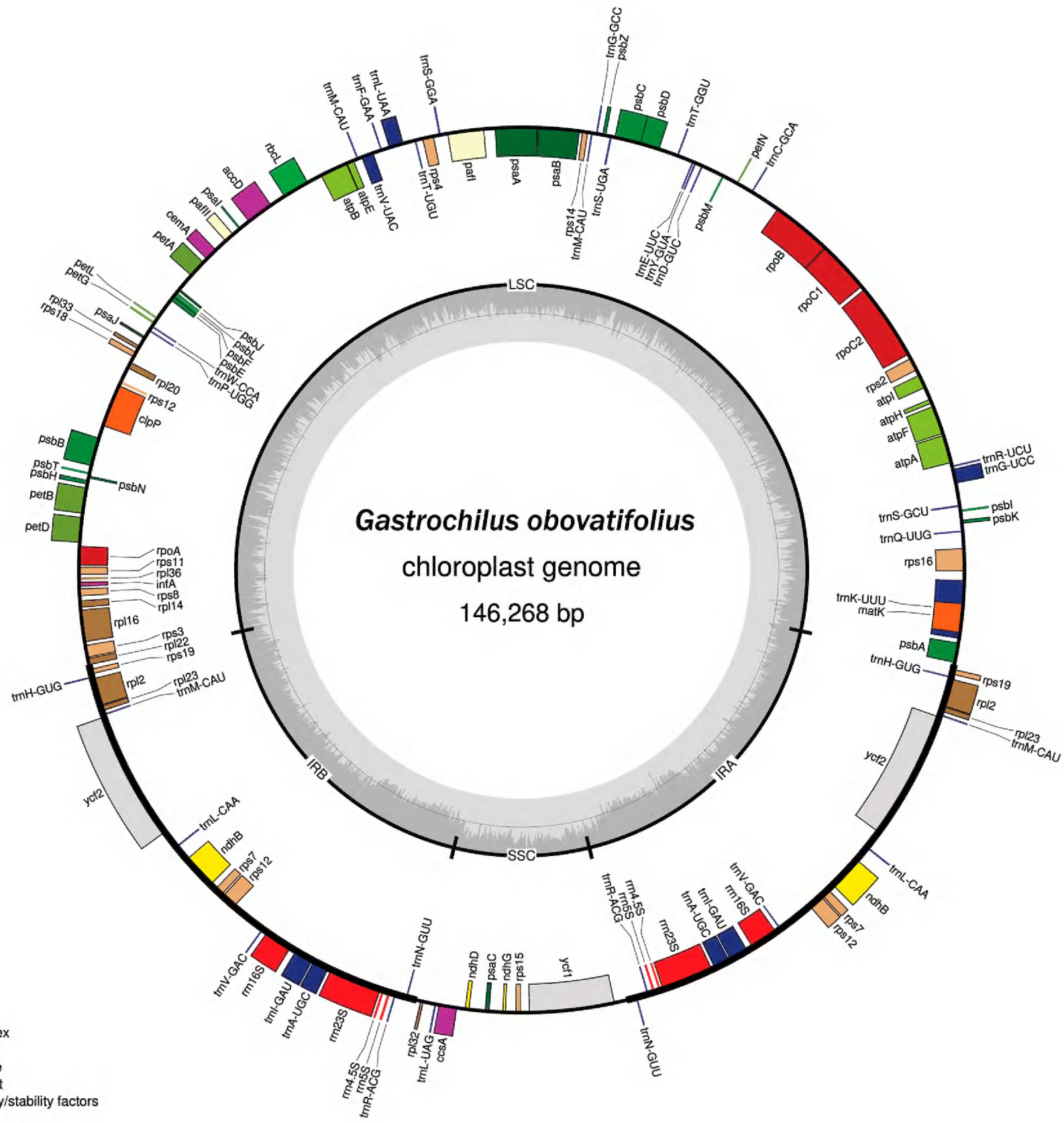

Figure 1. Plastome map of *Gastrochilus obovatifolius*. The thick lines on the outer complete circle represent the inverted repeat regions (IRa and IRb). The gray gradient in the innermost circle represents the GC content. Genes on the outside and inside of the map are transcribed in clockwise and counter directions, respectively.

matrix including 3,431 nucleotides in length with 343 variable sites, consists of 805 bp for *mat*K, 677 bp for *psb*A–*trn*H, 950 bp for *psb*M–*trn*D, and 999 bp for *trn*L–F, respectively. The characteristics and statistics of the five plastid markers are summarized in Suppl. material 4. The resulting tree topology (Fig. 2) aligns with previous phylogenetic analyses of *Gastrochilus* (Zhang et al. 2024a, b). The new species and *G. balangshanensis* Jun Y.Zhang, B.Xu & Yue H.Cheng form a monophyletic pair (PP/BS = 0.94/82) sister to *G. heminii* and *G. bernhardtianus* (PP/BS = 0.56/42), within *G.* sect. *Microphylli* (PP/BS = 0.79/89) (Fig. 2).

A morphological comparison of *G. obovatifolius*, *G. balangshanensis*, *G. heminii*, and *G. affinis* is presented in Table 1, which further substantiates the recognition of *G. obovatifolius* as a new species.

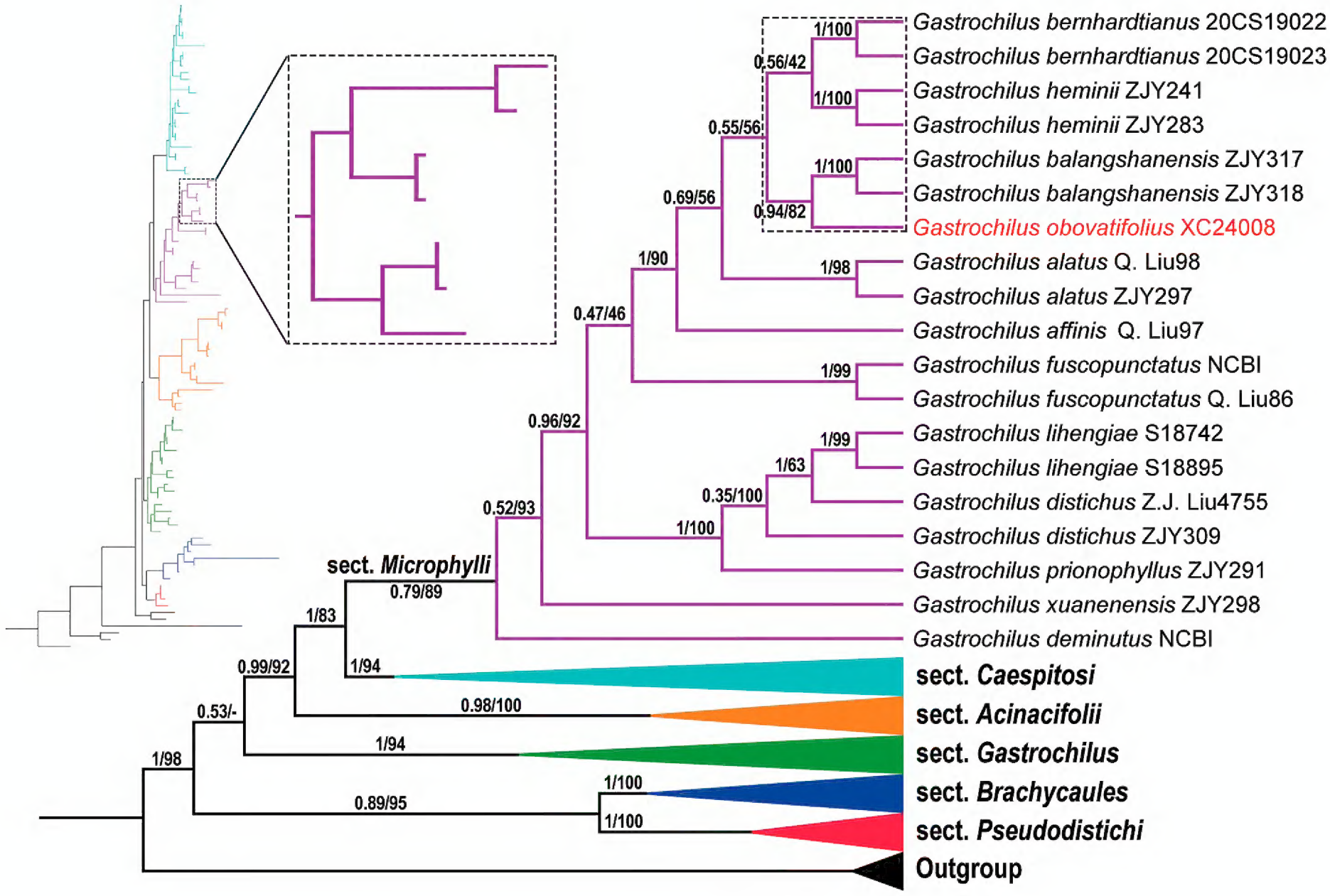

Figure 2. Bayesian tree from analysis of combined nrITS and four-plastid (*mat*K, *psb*A–*trn*H, *psb*M–*trn*D, and *trn*L–F) marker data of 55 species of *Gastrochilus*. The bootstrap values (BS) of ML and posterior probabilities (PP) of BI are listed at each node. The new species is highlighted in red, dotted lines shows its phylogenetic relationship with three related species.

Table 1. Morphological comparison between *Gastrochilus obovatifolius* and three morphologically similar species in *G.* sect. *Microphylli*.

Characters	*G. obovatifolius*	*G. affinis*	*G. balangshanensis*	*G. heminii*
Leaves	obovate, 1.4–1.6 × 0.6–0.8 cm	elliptic to narrowly oblong, 1.2–2.6 × 0.3–0.7 cm	nearly elliptic, 0.9–1.5 × 0.4–0.8 cm	narrowly oblong or oblong-falcate, 0.9–2.3 × 0.3–0.5 cm
Dorsal sepal	elliptic, ca. 5.0 × 4.0 mm, apex obtuse	elliptic-oblong, 3.0–5.0 × 1.0–1.3 mm, apex obtuse	elliptic, 5.6–6.4 × 4.8–5.2 mm, apex obtuse	elliptic-oblong, ca. 2.4 × 1.5 mm, apex obtuse
Lateral sepals	elliptic, slightly oblique, ca. 5.0 × 3.0 mm, apex obtuse	elliptic-ovate, slightly oblique and incurved, 3.5–4 × 0.7–1.3 mm, apex obtuse	elliptic, 5.6–6.4 × 4.8–5.2 mm, apex obtuse	elliptic-oblong, ca. 2.4 × 1.5 mm, apex obtuse
Petals	oblong, ca. 6.0 × 3.0 mm	ovate-elliptic to elliptic, 3.0.–4.0 × 1.0–1.3 mm	oblong, 5.0–5.8 × 4.0–4.4 mm	narrowly oblong, ca. 2.6 × 1.3 mm
Epichile	reniform, 10.0–12.0 × 6.0–8.0 mm, revolute, margin erose, median patch dark purple with 2 low ridges	subtriangular, ca. 8.0 × 4.5 mm, decurved, margin finely erose at base, median patch brown to purplish-brown, with 2 thick ridges	reniform, 10.0–12.0 × 5.5–6.5 mm, revolute, margin erose, median patch purple-red with two inconspicuous ridges	reniform, 4.2–6.5 × 2.0–3.0 mm, revolute, margin erose, median patch purple-red with irregular folds
Hypochile	sub-hemispherical, 4.0–4.5 × 4.0–4.2 mm, dorsally compressed, slightly bent outward, obtuse at the apex	obconical, 3.0–4.0 × 2.0–3.0 mm, dorsally compressed, slightly bent outward, subacute to obtuse and shortly bifid at apex	sub-hemispherical, 6.0–8.0 × 5.8–7.5 mm, dorsally compressed, obtuse-rounded at the apex	subconical, 2.0–2.4 × 1.6–2.0 mm, dorsally compressed, slightly bent outward, splits into two conical sacs at the apex
Distribution	Chengkou, NE. Chongqing	Gaoligongshan, NW. Yunnan, Xizang; India, Nepal	Wenchuan, Central Sichuan	Wenchuan, Central Sichuan

Taxonomic treatment

Gastrochilus obovatifolius **C.Xiong, X.Y.Fu & S.R.Yi, sp.nov.**
urn:lsid:ipni.org:names:77356371-1
Figs 3, 4

Diagnosis. *Gastrochilus obovatifolius* is most similar to *G. balangshanensis*., but differs by the longer stem (3–5 vs. 1.5–3.5 cm), obovate leaves (vs. nearly elliptic), and smaller sepals (ca. 5.0 × 3.0–4.0 vs. 5.6–6.4 × 4.8–5.2 mm) and hypochile (4.0–4.5 × 4.0–4.2 vs. 6.0–8.0 × 5.8–7.5 mm).

Type. China • Chongqing: Chengkou County (城口县), Dong'an Town (东安镇), Lizishuping (栗子树坪), 31°42'N, 109°11'E, alt. ca. 1650 m, 30 March 2024, *Si-Rong Yi et al. YSR2703* (holotype IBK!, isotype CGMC!).

Description. ***Epiphytic herbs***, monopodial, pendent, with a short stem, 3.0–5.0 cm long, leafy. ***Roots*** vermiform, slender, 4.0–6.0 cm long and ca. 1 mm in diameter. ***Stems*** short, branched, green, glabrous, up to 5 cm long and ca. 2.0 mm in diameter, covered with sheathing leaf bases; sheaths with purplish-red spots; internodes 1.2–1.8 mm long. ***Leaves*** alternate, distichous, obovate, fleshy, 1.4–1.6 × 0.6–0.8 cm, margin entire, apex acute, obscurely serrate; young leaves yellow-green with a few purplish-red spots, mature leaves green with hardly any purplish-red spots. ***Inflorescences*** 1–2 racemes, usually arising from the axil of an upper leaf, 2.0–2.5 cm long, 1–2-flowered; peduncle 0.8–1.2 cm long; bracts 1.0–2.0 mm long. ***Flowers*** 1.2–1.4 × 1.0–1.2 cm, yellow-green, with dark purple stripes on petals and sepals, raised abaxially along the midrib; pedicel and ovary yellowish-green with purple-red spots, 1.5–1.6 cm long. ***Dorsal sepal*** elliptic, concave, ca. 5.0 × 4.0 mm, apex obtuse; ***lateral sepals*** similar to dorsal sepal, slightly oblique, ca. 5.0 × 3.0 mm, apex obtuse; petals oblong, concave, ca. 6.0 × 3.0 mm, apex obtuse. ***Labellum*** epichile reniform, yellow-green with purplish-red spots, 1.0–1.2 × 0.6–0.8 cm, revolute, margin erose, smooth and glabrous above, median patch, thickened, with 2 low ridges, dark purple; hypochile sub-hemispherical, yellow-green, mouth with lateral purplish-red markings, sac with purplish-red spots on the underside, obtuse at the apex, 4.0–4.5 mm tall, 4.0–4.2 mm in diameter, dorsally compressed, slightly bent outward. ***Column*** stout, ca. 2.0 × 1.2 mm; rostellum bilobed; anther cap galeate with curved emarginate beak, ca. 1.0 × 1.2 mm; pollinia 2, ca. 0.8 × 0.6 mm, yellow, nearly spherical, entire, with a depression in the center; stipe elongate, ca. 1.2 mm long, viscidium yellow, elliptic, ca. 0.8 × 0.4 mm. ***Capsule*** not seen.

Phenology. Flowering from March to April.

Etymology. The specific epithet '*obovatifolius*' refers to the highly distinctive obovate leaves. The suggested Chinese common name is "dào luǎn yè pén jù lán (倒卵叶盆距兰)".

Distribution and ecology. The new species has only been recorded in Chengkou County, northeast Chongqing Municipality, bordering Shaanxi Province, China (Fig. 6). It grows as a trunk epiphyte on *Quercus engleriana* Seemen, in evergreen broad-leaved forest at an elevation of 1620–1650 m a.s.l. (Fig. 5). Besides *Q. engleriana*, the most frequent co-occurring angiosperm species include *Fargesia spathacea* Franch., *Hepatica henryi* (Oliv.) Steward, *Pieris japonica* (Thunb.)

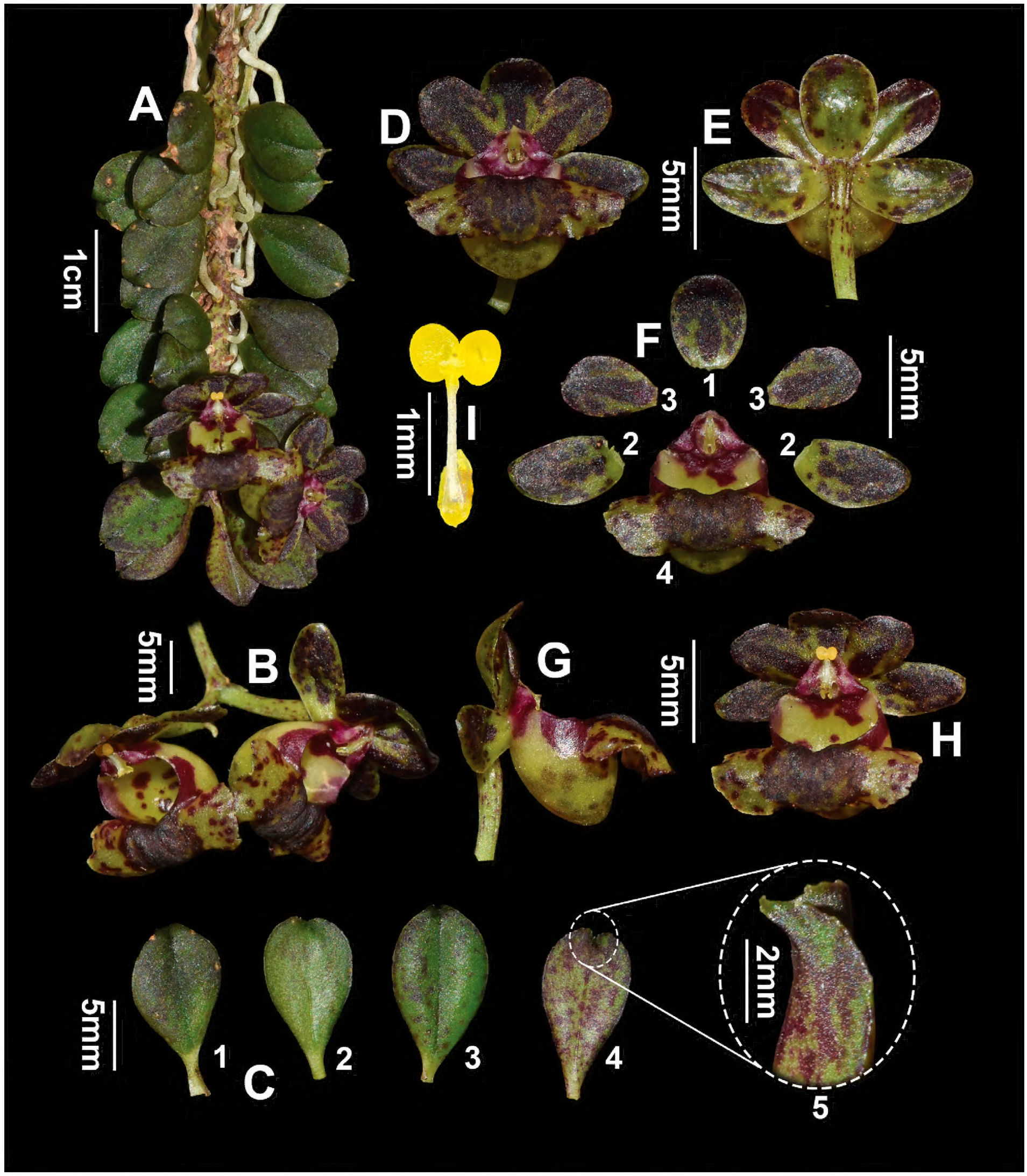

Figure 3. *Gastrochilus obovatifolius* C.Xiong, X.Y.Fu & S.R.Yi, sp. nov. *in vivo*. **A** flowering plant **B** inflorescence **C** leaves (C1–C3: front view, C4: back view, C5: close-up of leaf apex) **D** flower (front view) **E** flower (back view) **F** dissected flower (F1: dorsal sepal; F2: lateral sepals; F3: petals; F4: labellum) **G** flower (side view) **H** flower (top view) **I** pollinarium.

D. Don ex G. Don, *Rhododendron adenopodum* Franch., and *Zanthoxylum dimorphophyllum* Hemsl.

Additional specimens examined (paratypes). China • Chongqing: Chengkou County (城口县), Dong'an Town (东安镇), Dongjiachang (董家厂), 31°42'N, 109°12'E, alt. ca. 1620 m, 8 April 2024, *Si-Rong Yi et al. YSR2733* (IBK!, CGMC!).

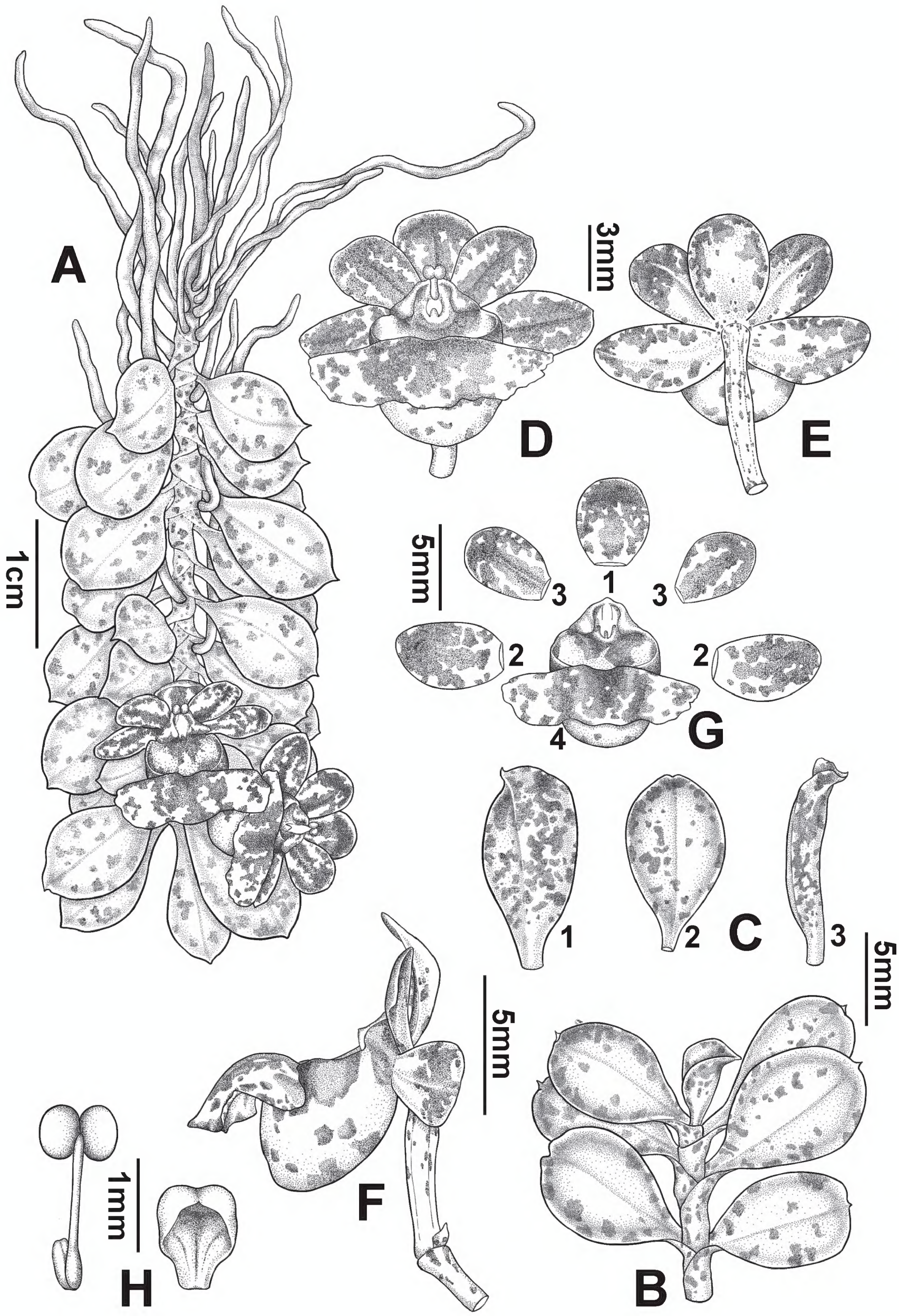

Figure 4. *Gastrochilus obovatifolius* C.Xiong, X.Y.Fu & S.R.Yi, sp. nov., an overview **A** habit **B** stem apex **C** leaves (C1: front view, C2: back view, C3: side view) **D** flower (side view) **E** flower (front view) **F** flower (back view) **G** dissected flower (G1: dorsal sepal; G2: lateral sepals; G3: petals; G4: labellum) **H** pollinarium and anther cap.

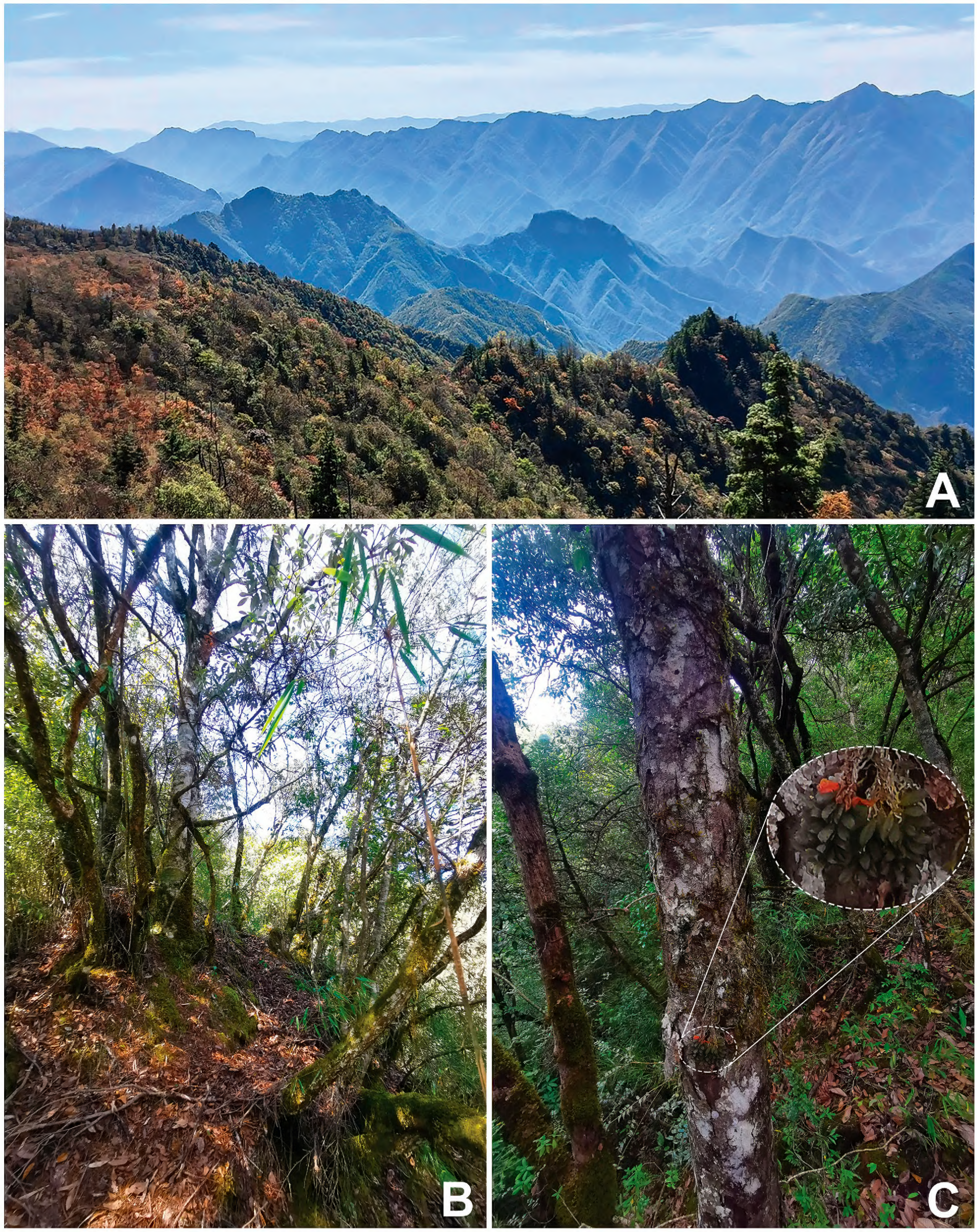

Figure 5. *Gastrochilus obovatifolius*, habitat and plants in situ. **A** broad-leaved temperate forest in the Daba Mountains of Chongqing **B** a woodland trail lined with *Fargesia spathacea*, *Quercus engleriana*, *Pieris japonica*, *Rhododendron adenopodum*, and *Zanthoxylum dimorphophyllum* **C** *G. obovatifolius* growing as a trunk epiphyte on *Q. engleriana*.

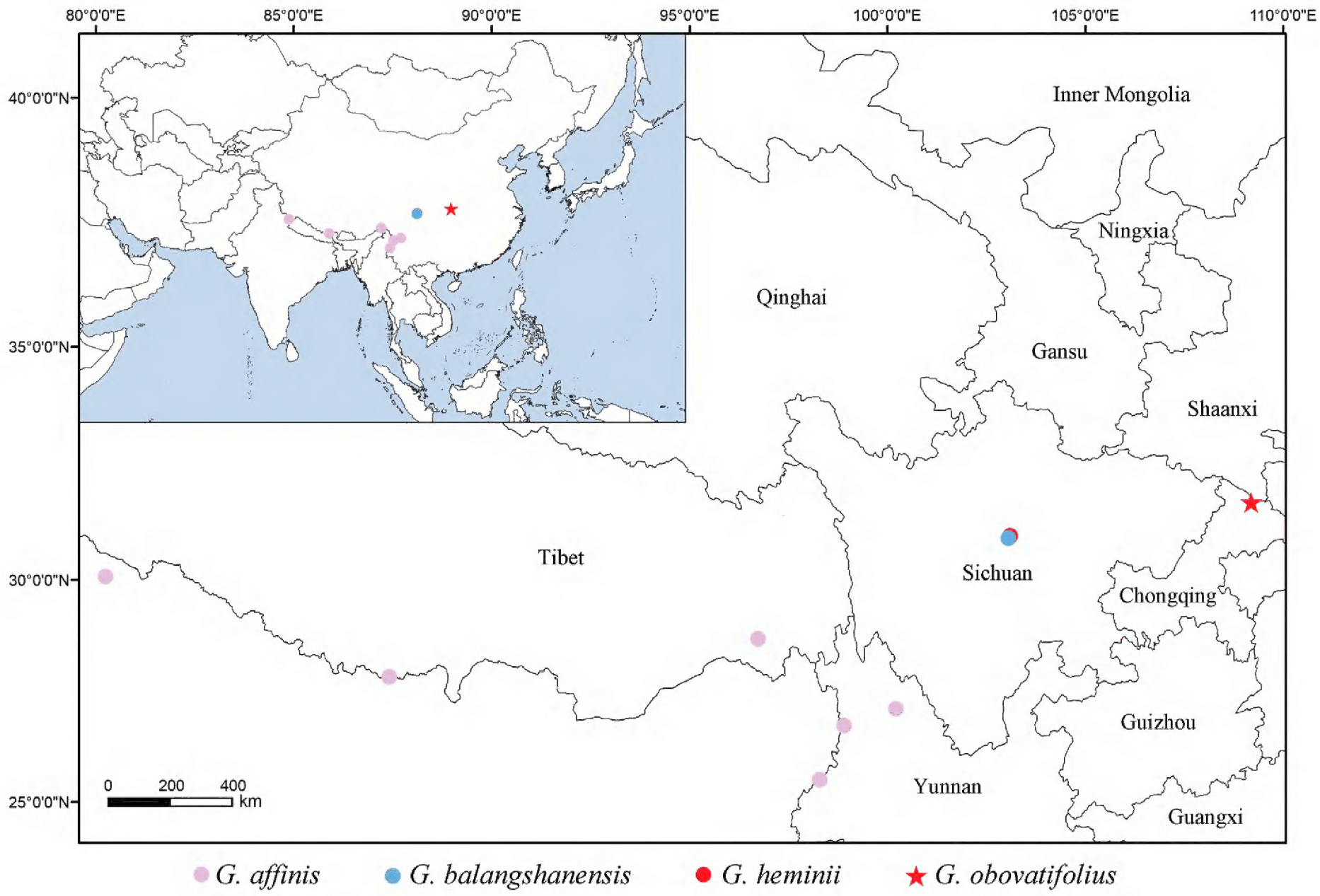

Figure 6. Distribution map of *Gastrochilus obovatifolius* and three related species of *G.* sect. *Microphylli* in southwestern China and adjoining areas.

Discussion

The phylogenetic analysis revealed that the newly discovered *Gastrochilus obovatifolius*, along with 12 other *Gastrochilus* species (comprising 19 accessions), form a clade classified as *Gastrochilus* sect. *Microphylli*. This clade is distinguished by floral characteristics such as diminutive flowers (petals and sepals < 6 mm long), a nearly reniform glabrous epichile with central irregular projections, and in some species, a hypochile split into two conical protrusions (Zhang et al. 2024a). The obovate leaves of *G. obovatifolius* set it apart from any other species in *Gastrochilus* sect. *Microphylli*, which predominantly exhibit lanceolate, oblong, or ovate leaves.

Gastrochilus sect. *Microphylli* now encompasses a total of 16 species, including 13 distributed in southern and southwestern China. Among these 13 species, only *G. xuanenensis* Z. H. Tsi (Tsi 1982) and the newly described *G. obovaifolius* are known to be restricted to the Qinling-Daba Mountains (QDM), while the Hengduan Mountains (HDM) harbor a greater diversity, with 11 out of the 13 identified species (Zhang et al. 2024b). The high endemism rate in the QDM and its adjacent regions (Zhang et al. 2022a, b), contrasts with the relatively low diversity of *G.* sect. *Microphylli* species in this area, which may suggest some potential for the identification of new species. Accordingly, there

is a pressing need for further field research and investigations focused on *Gastrochilus* and other epiphytic orchids in this region.

In Chengkou County, where *G. obovatifolius* was discovered, two other species of *Gastrochilus* are present: *G. fargesii* (Kraenzl.) Schltr. and *G. formosanus* (Hayata) Hayata. These species are classified under *G.* sect. *Acinacifolii* and *G.* sect. *Caespitosi*, respectively. They can be easily differentiated from *G. obovatifolius* by their foliar and floral characteristics, including the longer leaves (5–15 cm long) and the differently textured epichile, which is densely covered with papillate hairs.

Acknowledgments

We greatly thank Jun-Yi Zhang for facilitating the sequence data on *G. balangshanensis* and Zhang-Jie Huang for his valuable suggestions on the Latin name of this species.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

This study received financial support from the Study on Economic Plant Resources in the Three Gorges Reservoir Area in Chongqing and the Basic Research Fund of the Guangxi Academy of Sciences (CQZ-C-1901).

Author contributions

Conceptualisation and Methodology: Chi Xiong. Investigation: Ya Huang, Hong-Jing Zhang, Si-Rong Yi. Data Curation: Xiao-Ying Fu, Yi-Chen Wang, Yu-Bing Yang. Software and Visualisation: Xiao-Ying Fu, Ke Tan. Writing-Original draft: Chi Xiong, Xiao-Ying Fu. Writing-Review and Editing: Ke Tan, Si-Rong Yi. All authors have read and approved the final manuscript.

Author ORCIDs

Chi Xiong https://orcid.org/0000-0002-9082-2539
Xiao-Ying Fu https://orcid.org/0009-0009-1090-877X
Ke Tan https://orcid.org/0000-0002-9036-163X
Ya Huang https://orcid.org/0000-0003-3939-4046
Hong-Jing Zhang https://orcid.org/0000-0003-0025-9269
Yi-Chen Wang https://orcid.org/0000-0001-9541-975X
Yu-Bing Yang https://orcid.org/0000-0002-2742-6701
Si-Rong Yi https://orcid.org/0000-0002-3883-6175

Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

References

Averyanov LV, Maisak TV, Nguyen TLT, Truong BV (2022) *Gastrochilus pankajkumarii*, (Aeridinae, Epidendroideae, Orchidaceae) a new lithophytic orchid from southern Vietnam. Taiwania 67(1): 35–39. https://doi.org/10.6165/tai.2022.67.35

Beentje H (2016) The Kew plant glossary: an illustrated dictionary of plant terms, 2nd ed. Kew Publishing, Kew, 184 pp.

Bengtsson-Palme J, Ryberg M, Hartmann M, Branco S, Wang Z, Godhe A, Wit PD, Sanchez-Garcia M, Ebersberger I, Sousa F, Amend AS, Jumpponen A, Unterseher M, Kristiansson E, Abarenkov K, Bertrand Y, Sanli K, Eriksson KM, Vik U, Veldre V, Nilsson RH (2013) Improved software detection and extraction of ITS1 and ITS2 from ribosomal ITS sequences of fungi and other eukaryotes for analysis of environmental sequencing data. Methods in Ecology and Evolution 4(10): 914–919. https://doi.org/10.1111/2041-210X.12073

Chase MW, Hills H (1991) Silica gel: An ideal material for field preservation of leaf samples for DNA studies. Taxon 40(2): 215–220. https://doi.org/10.2307/1222975

Chen SC, Tsi ZH, Wood JJ (2009) *Gastrochilus* D. Don. In: Wu ZY, Raven PH, Hong DY (Eds) Flora of China Vol. 25 (Orchidaceae). Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, 491–498.

Chen LY, Song MS, Zha HG, Li ZM (2014) A modified protocol for plant genome DNA extraction. Plant Diversity and Resources 36: 375–380. https://doi.org/10.7677/ynzwyj201413156

Chen WS, Lei M, Ma CB, Jin XH, Wang XL (2022) *Gastrochilus xizangensis* (Aeridinae, Vandeae, Orchidaceae), a new species from Xizang, China. Phytotaxa 566(2): 219–226. https://doi.org/10.11646/phytotaxa.566.2.6

Dey S, Phom L, Bhattacharjee A, Eshuo K (2022) *Gastrochilus pseudocalceolaris*, a new species of epiphytic orchid from India. Phytotaxa 574(4): 295–300. https://doi.org/10.11646/phytotaxa.574.4.5

Don D (1825) *Gastrochilus*. In: David D, Francis H, Wallich N (Eds) Prodromus florae Nepalensis. J. Gale, London, 32 pp.

Greiner S, Lehwark P, Bock R (2019) OrganellarGenomeDRAW (OGDRAW) version 1.3. 1: Expanded toolkit for the graphical visualization of organellar genomes. Nucleic Acids Research 47(W1): W59–W64. https://doi.org/10.1093/nar/gkz238

Guindon S, Dufayard JF, Lefort V, Anisimova M, Hordijk W, Gascuel O (2010) New algorithms and methods to estimate maximum-likelihood phylogenies: Assessing the performance of PhyML 3.0. Systematic Biology 59(3): 307–321. https://doi.org/10.1093/sysbio/syq010

Jin JJ, Yu WB, Yang JB, Song Y, DePamphilis CW, Yi TS, Li DZ (2020) GetOrganelle: A fast and versatile toolkit for accurate de novo assembly of organelle genomes. Genome Biology 21(1): 1–31. https://doi.org/10.1186/s13059-020-02154-5

Kalyaanamoorthy S, Minh BQ, Wong TKF, Haeseler A, Jermiin LS (2017) ModelFinder: fast model selection for accurate phylogenetic estimates. Nature methods 14(6): 587–589. https://doi.org/10.1038/nmeth.4285

Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: Improvements in performance and usability. Molecular Biology and Evolution 30(4): 772–780. https://doi.org/10.1093/molbev/mst010

Lee YI, Yu SK, Liao PC, Wang KH, Lin TP (2019) Newly discovered native orchids of Taiwan (XIV). Taiwania 64(4): 339–346. https://doi.org/10.6165/tai.2019.64.339

Lee CT, Wu JH, Wang YQ, Hsieh SI (2023) *Gastrochilus yehii* sp. nov. (Orchidaceae) from Taiwan. Phytotaxa 587(1): 53–58. https://doi.org/10.11646/phytotaxa.587.1.7

Li JW, Ya JD, Ye DP, Liu C, Liu Q, Pan R, Zhang ZX, Pan B, Lin DL, Jin XH (2021) Taxonomy notes on Vandeae (Orchidaceae) from China: Five new species and two new records. Plant Diversity 43(5): 379–389. https://doi.org/10.1016/j.pld.2021.01.009

Li Y, Jin WT, Zhang LG, Zhou P, Luo Y, Zhu ZW, Xiang XG (2022) Biogeography and diversification of the tropical and subtropical Asian genus *Gastrochilus* (orchidaceae, aeridinae). Diversity 14(5): 396. https://doi.org/10.3390/d14050396

Li MK, Yu YP, Ma PY, Chen XD, Deng JP, Liu Q, Luo Y, Xing Z (2023) *Gastrochilus linzhiensis* (Aeridinae, Vandeae, Epidendroideae, Orchidaceae), a new species from Xizang, China. Taiwania 68(3): 314–317. https://doi.org/10.6165/tai.2023.68.314

Liao M, Cheng YH, Zhang JY, Feng Y, Liu GY, Ye P, Jin SL, Lin HQ, Xu B (2022) *Gastrochilus heminii* (Orchidaceae, Epidendroideae), a new species from Sichuan, China, based on molecular and morphological data. PhytoKeys 215: 95–106. https://doi.org/10.3897/phytokeys.215.91061

Liu Q (2017) Taxonomic Revision Study of *Gastrochilus* D. Don (Orchidaceae) in China. Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Yunnan, China, 1–145.

Liu Q, Song Y, Jin XH, Gao JY (2019) Phylogenetic relationships of *Gastrochilus* (Orchidaceae) based on nuclear and plastid DNA data. Botanical Journal of the Linnean Society 189(3): 228–243. https://doi.org/10.1093/botlinnean/boy084

Liu Q, Wu XF, Zhou SS, Li JW, Jin XH (2023) New species and record of *Gastrochilus* (Orchidaceae, Aeridinae) from China and Laos. Phytotaxa 585(3): 210–224. https://doi.org/10.11646/phytotaxa.585.3.3

Minh BQ, Nguyen MA, Haeseler A (2013) Ultrafast approximation for phylogenetic bootstrap. Molecular Biology and Evolution 30(5): 1188–1195. https://doi.org/10.1093/molbev/mst024

Nguyen LT, Schmidt HA, Haeseler A, Minh BQ (2015) IQ-TREE: A fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. Molecular Biology and Evolution 32(1): 268–274. https://doi.org/10.1093/molbev/msu300

Nguyen DH, Averyanov LV, Dang VS, Bui VH, Maisak T, Truong BV (2021) *Gastrochilus dresslerii* (Orchidaceae), a new species from northern of Vietnam. Phytotaxa 498(2): 145–149. https://doi.org/10.11646/phytotaxa.498.2.8

Ormerod P, Kumar CS (2020) A new Bhutanese *Gastrochilus* (Orchidaceae), and another transfer in Indian *Cylindrolobus*. Harvard Papers in Botany 25(1): 125–127. https://doi.org/10.3100/hpib.v25iss1.2020.n16

POWO (2024) Plants of the World Online. https://powo.science.kew.org [accessed 5 October 2024]

Rao WH, Liu ZJ, Zhang GQ, Chen XH, Huang J, Chen GZ, Chen LJ (2019) A new epiphytic species of *Gastrochilus* (Orchidaceae: Epidendroideae) from Yunnan, China. Phytotaxa 413(4): 296–300. https://doi.org/10.11646/phytotaxa.413.4.5

Ronquist F, Teslenko M, Van Der Mark P, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. Systematic Biology 61(3): 539–542. https://doi.org/10.1093/sysbio/sys029

Seidenfaden G (1988) Orchid genera in Thailand XIV. Fifty-nine vandoid genera. Opera Botanica 95: 1–398.

Shi LC, Chen HM, Jiang M, Wang LQ, Wu X, Huang LF, Liu C (2019) CPGAVAS2, an integrated plastome sequence annotator and analyzer. Nucleic Acids Research 47(W1): W65–W73. https://doi.org/10.1093/nar/gkz345

Thiers B (2024) Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/ [accessed 5 October 2024]

Tillich M, Lehwark P, Pellizzer T, Ulbricht-Jones ES, Fischer A, Bock R, Greiner S (2017) GeSeq–versatile and accurate annotation of organelle genomes. Nucleic Acids Research 45(W1): W6–W11. https://doi.org/10.1093/nar/gkx391

Tsi ZH (1982) Two new species of Orchidaceae from China. Yunnan Zhi Wu Yan Jiu 4(03): 267–270.

Tsi ZH (1996) A preliminary revision of *Gastrochilus* (Orchidaceae). Guangxi Zhi Wu 16: 123–154.

Tsi ZH (1999) *Gastrochilus* D. Don. In: Tsi ZH (Ed.) Flora Reipublicae Popularis Sinicae, Vol. 19. Science Press, Beijing, 399–420.

Wu XF, Ye DP, Pan B, Lin XQ, Jiang H, Liu Q (2019) Validation of *Gastrochilus prionophyllus* (Vandeae, Orchidaceae), a new species from Yunnan province, China. PhytoKeys 130: 161–169. https://doi.org/10.3897/phytokeys.130.34555

Xiang CY, Gao FL, Jakovlić I, Lei HP, Hu Y, Zhang H, Zou H, Wang GT, Zhang D (2023) Using PhyloSuite for molecular phylogeny and tree-based analyses. iMeta 2(1): e87. https://doi.org/10.1002/imt2.87

Ya JD, Wang WT, Liu YL, Jiang H, Han ZD, Zhang T, Huang H, Cai J, Li DZ (2023) Five new and noteworthy species of Epidendroideae (Orchidaceae) from southwestern China based on morphological and phylogenetic evidence. PhytoKeys 235: 211–236. https://doi.org/10.3897/phytokeys.235.111230

Zhang BP (2019) Ten major scientific issues concerning the study of China's north-south transitional zone. Progress in Geography 38(3): 305–311. https://doi.org/10.18306/dlkxjz.2019.03.001

Zhang D, Gao FL, Jakovlic I, Zou H, Zhang J, Li WX, Wang GT (2020) PhyloSuite: An integrated and scalable desktop platform for streamlined molecular sequence data management and evolutionary phylogenetics studies. Molecular Ecology Resources 20(1): 348–355. https://doi.org/10.1111/1755-0998.13096

Zhang JY, Cheng YH, Liao M, Feng Y, Jin SL, Qu CM, Tan YC, Anđelka PM, Xu B (2022) *Gastrochilus wolongensis* (Orchidaceae): A new species from Sichuan, China, based on molecular and morphological data. Ecosystem Health and Sustainability 8(1): 2101546. https://doi.org/10.1080/20964129.2022.2101546

Zhang XH, Zhang BP, Li JY, Yao YH, Wang J, Liu JJ, Yu FQ (2022a) A database of seed plants on taxonomy, geography and ecology in the Qinling-Daba Mountains and adjacent areas. Scientific Data 9(1): 672. https://doi.org/10.1038/s41597-022-01810-8

Zhang XH, Zhang BP, Yao YH, Liu JJ, Wang J, Yu FQ, Li JY (2022b) Variation model of north-south plant species diversity in the Qinling-Daba Mountains in China. Global Ecology and Conservation 38: e02190. https://doi.org/10.1016/j.gecco.2022.e02190

Zhang JY, Cheng YH, Liao M, Feng Y, Jin SL, He TM, He H, Xu B (2024a) A new infrageneric classification of *Gastrochilus* (Orchidaceae: Epidendroideae) based on molecular and morphological data. Plant Diversity 46(4): 435–447. https://doi.org/10.1016/j.pld.2023.08.001

Zhang JY, Cheng YH, Liao M, Jin SL, Lin HQ, Yang PY, He H, Xu B (2024b) *Gastrochilus balangshanensis* (Orchidaceae, Aeridinae), a new subalpine epiphytic orchid from the

Mountains of Southwest China. PhytoKeys 247: 123–135. https://doi.org/10.3897/phytokeys.247.130755

Zhou CY, Zeng MY, Wu YW, Li MH (2024) *Gastorchilus pseudodresslerii* (Orchidaceae; Vandeae), a new species from China: Evidence from morphological and DNA analysis. Phytotaxa 634(1): 71–78. https://doi.org/10.11646/phytotaxa.634.1.6

Zhu K (1958) Subtropical zone of China. Chinese Science Bulletin 9: 524–528. https://doi.org/10.1360/csb1958-3-17-524

Supplementary material 1

Detailed information of material, voucher and GenBank accession numbers

Authors: Chi Xiong, Xiao-Ying Fu, Ke Tan, Ya Huang, Hong-Jing Zhang, Yi-Chen Wang, Yu-Bing Yang, Si-Rong Yi

Data type: docx

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/phytokeys.252.133501.suppl1

Supplementary material 2

Genes encoded in the plastid genome of *Gastrochilus obovatifolius* C.Xiong, X.Y.Fu & S.R.Yi

Authors: Chi Xiong, Xiao-Ying Fu, Ke Tan, Ya Huang, Hong-Jing Zhang, Yi-Chen Wang, Yu-Bing Yang, Si-Rong Yi

Data type: docx

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/phytokeys.252.133501.supp2

Supplementary material 3

Summary of the whole plastid genome of *Gastrochilus obovatifolius* C.Xiong, X.Y.Fu & S.R.Yi

Authors: Chi Xiong, Xiao-Ying Fu, Ke Tan, Ya Huang, Hong-Jing Zhang, Yi-Chen Wang, Yu-Bing Yang, Si-Rong Yi

Data type: docx

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/phytokeys.252.133501.suppl3

Supplementary material 4

Statistics for the molecular datasets used in this study

Authors: Chi Xiong, Xiao-Ying Fu, Ke Tan, Ya Huang, Hong-Jing Zhang, Yi-Chen Wang, Yu-Bing Yang, Si-Rong Yi

Data type: docx

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/phytokeys.252.133501.suppl4